Opportunities and Challenges in Land Data Assimilation

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Advances in terrestrial remote sensing and modeling techniques have recently converged to support routine land data assimilation to support a variety of Earth science applications, including numerical weather prediction, seasonal-to-interannual forecasting, assessment of water resources and agricultural productivity, among others.. The original Land Data Assimilation systems (LDAS) such as the North American Land Data Assimilation System (NLDAS; Mitchell et al. 2004) and the Global Land Data Assimilation System (GLDAS; Rodell et al. 2004) focused primarily on improving numerical weather prediction skill by improving the characterization of the land surface conditions. These LDAS did not actually assimilate land surface state variables; rather, they sought to improve land states by improving water and energy boundary conditions (e.g. precipitation and radiation) as well as land surface parameters such as albedo, land cover, and vegetative greenness/leaf area index. These 1st generation LDAS, coupled with advances in techniques for assilmilating land surface state variables such as snow cover, snow water equivalent, soil moisture, and terrestrial water storage, have laid the groundwork for what I will call 2nd generation LDAS.

The Land Information System (LIS; http://lis.gsfc.nasa.gov; Kumar et al., 2006; Peters-Lidard et al., 2007) is a flexible land surface modeling framework that has been developed with the goal of supporting true land data assimilation. By consolidating the Goddard Modeling and Assimilation Office's Ensemble Kalman Filter (EnKF), LIS has recently been demonstrated for multi-model data assimilation of soil moisture, snow, and temperature (Kumar et al., 2008). Ongoing work has demonstrated the value of bias correction as part of the filter, and also that of joint calibration and assimilation. Both 1st generation LDAS described above (GLDAS and NLDAS) now use specific configurations of the LIS software in their current implementations. In addition, LIS was recently transitioned into operations at the US Air Force Weather Agency (AFWA) to ultimately replace their Agricultural Meteorology (AGRMET) system, and is also used routinely by NOAA's National Centers for Environmental Prediction (NCEP)/Environmental Modeling Center (EMC) for their land data assimilation systems to support weather and climate modeling. LIS not only consolidates the capabilities of these two systems, but also enables a much larger variety of configurations with respect to horizontal spatial resolution, input datasets and choice of land surface model through "plugins". As described in Kumar et al., 2007, and demonstrated in Case et al., 2008, and Santanello et al., 2009, LIS has been coupled to the Weather Research and Forecasting (WRF) model to support studies of land-atmosphere coupling be enabling ensembles of land surface states to be tested against multiple representations of the atmospheric boundary layer. LIS has also been demonstrated for parameter estimation as described in Peters-Lidard et al. (2008) and Santanello et al. (2007), who showed that the use of sequential remotely sensed soil moisture products can be used to derive soil hydraulic and texture properties given a sufficient dynamic range in the soil moisture retrievals and accurate precipitation inputs.

Examples and case studies demonstrating the capabilities and impacts of LIS as examples of the sort of opportunities and challenges for 3nd generation LDAS, which will include simultaneous optimization and data assimilation for water, energy, and carbon cycle science and applications.

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